Docket No.: A-2570

CERTIFICATION

I, the below named translator, hereby declare that: my name and post office address are as stated below; that I am knowledgeable in the English and German languages, and that I believe that the attached text is a true and complete translation of German Application No. 199 49 750.8, filed October 15, 1999.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Hollywood, Florida

Christine Kahl

June 12, 2003

Lerner & Greenberg, P.A.
P.O. 2480
Hollywood, FL 33022-2480
Tel.: (954) 925-1100
Fax.: (954) 925-1101

A-2570

MODULAR PRINTING MACHINE SYSTEM FOR PRINTING ON SHEETS

Description

The invention relates to a modular printing machine system for printing on sheets, comprising a first printing machine of satellite design, with a central first impression cylinder and at least four printing devices assigned to the latter, a second printing machine, and a coupling device for coupling the printing machines to one another for their in-line operation, according to the preamble of claim 1.

US 5,660,108 describes such a system, which comprises a first printing machine and a second printing machine which are of identical construction. Each of the two printing machines includes ink fountains, whose metering devices are designed in accordance with US 4,058,058, so that by using each metering device, not only the quantity of ink delivered to the plate cylinder but also its zonal ink distribution can be regulated. Metering devices of this type are needed in order that each printing machine can be used for printing four-color images in the offset process. Although the second printing machine is designed as a universal machine, by means of which not only can four-color images, but alternatively special inks or varnishes can also be printed, the metering devices of the second printing machine are not designed in an optimum way for printing special inks and varnishes.

Further prior art is described in DE 43 03 797 A1, DE 195 03 619 A1 and DE 197 43 770 A1.

On the basis of these inadequacies, the invention is based on the object of providing a modular printing machine system which is extremely suitable for printing special inks and for varnishing.

The object set is achieved by a modular printing machine system having the features of claim 1.

The invention is based on the finding that it is not advantageous to couple two identically designed universal machines to each other, as described in US 5,660,108, but that it is much more advantageous to include a special machine designed optimally for printing special inks or varnishes into the printing machine system.

The printing machine system according to the invention is distinguished by the fact that the second printing machine includes at least one metering device which is not subdivided into different metering elements that are assigned to individual inking zones and can be driven individually, and which preferably only has a single metering element reaching over the printing width. The thickness of the film of ink or varnish produced by the metering device is not only uniform over the entire printing width but is also very high. This is particularly advantageous, since prints using special inks or varnishing often require a high volume of ink or varnish per unit area of the printing-material surface. The metering element of the zoneless metering device may be formed by an engraved or anilox roll, on which a doctor rests and which is provided with dimples arranged in a uniform distribution in the circumferential surface. However, the metering element can also be formed by a metering roll, which, together with a further roll, forms a metering gap producing the film of ink or varnish.

Advantageous developments of the printing machine system according to the invention are mentioned in the subclaims.

Although the system mentioned in claim 10 constitutes a particularly advantageous development of the system mentioned in claim 1, the system mentioned in claim 10 is inventive even without the features contained in the characterizing part of claim 1, for which reason the reference of claim 10 back to claim 1 has been selected to be optional.

Further advantageous embodiments of the printing machine system according to the invention emerge from the description and the drawing, in which:

Figure 1 shows a first modular printing machine system,

Figure 2 shows a second modular printing machine system,

Figure 3 shows a third modular printing machine system, and

Figure 4 shows a fourth modular printing machine system.

Figures 1 to 4 illustrate a first printing machine 1 which, in order to form a modular printing machine system 2 to 5, can optionally be coupled to a second printing machine 6 (see Figure 1), to a second printing machine 7 (see Figure 2), to a second printing machine 8 (see Figure 3) or to a second printing machine 9 (see Figure 4), and which comprises a sheet feeder 10 and a sheet deliverer 11 and all the further subassemblies needed for operation separately from the second printing machine 6, 7, 8 or 9.

In addition, the first printing machine 1 comprises a common impression cylinder 12, around which four printing devices 13 to 16 are arranged, with which a sheet 17 resting on the impression cylinder 12 is printed successively with the colors black, cyan, magenta and yellow in the offset process, preferably using dry offset (i.e. without damping solution). Each of the printing devices 13 to 16 comprises a plate cylinder 18 and an applicator cylinder 19, on which a rubber blanket is spread out and which is used to transfer the respective ink from the plate cylinder 18 to the sheet 17. The circumference of the impression cylinder 12, which is equipped with four rows of grippers, is four times as large as the circumference of the plate cylinder 18, and also four times as large as the circumference of the applicator cylinder 19. Each plate cylinder 18 is assigned a laser source as an image-setting device 20 for setting an image, which is carried out within the printing machine 1 by means of laser radiation, and an inking unit 21 for inking it during printing. The first printing machine 1 may be a machine of the type "Quickmaster DI 46-4" produced by Heidelberger Druckmaschinen AG.

Each of the second printing machines 6 to 9 comprises a sheet deliverer 21 to 24 with a chain gripper, is also equipped with a chassis 25 to 28 which can be moved out if required, and has two side walls whose thickness and distance from each other correspond to those of the first printing machine 1, so that the second printing machine 6 to 9 can be docked without difficulty onto the first printing machine 1.

The second printing machines 6 and 7 are designed as varnishing machines and each include an impression cylinder 29 and 30 with grippers and in each case an applicator cylinder 31 and 32. In order to feed varnish, a roll rests on the applicator cylinder 31 and, as a metering roll 33, together

with a dip roll 35 that scoops the varnish out of a trough 34, forms a metering device 36 for producing a uniform film of varnish over the printing width. The second printing machine 7 also has such a zoneless metering device 37, which, in an anilox design, comprises an engraved roll 38 rolling on the applicator cylinder 32 and a doctor 39 resting on the latter as a chamber-type doctor. The circumferential length of each cylinder 29 to 32 and of the engraved roll 38 corresponds to that of the plate cylinder 18. On each of the applicator cylinders 31 and 32, a rubber blanket 40 for varnishing the entire area of the sheet 17, or a flexographic printing plate 41 for spot varnishing can optionally be spread. In the latter case, the applicator cylinder 31 and 32 is a plate cylinder. Of course, a special ink can be printed with each second printing machine 6 and 7 instead of the varnish.

The second printing machine 8 is a slightly modified single-color printing machine of the "Printmaster QM 46-1" type, and the second printing machine 9 is a slightly modified two-color printing machine of the "Printmaster QM 46-2" type, which are produced by Heidelberger Druckmaschinen AG. The abovementioned machine types can also form the basis for the second printing machines 6 and 7; the modifications which would have to be carried out for this purpose would then be somewhat more extensive.

Each of the second printing machines 8 and 9 comprises an applicator cylinder 42 and 43 which, as a blanket cylinder, transfers the ink from at least one printing plate cylinder 44, 45 and 46 to the sheet 17 resting on an impression cylinder 47 and 48 in the offset process. The applicator cylinder 43 operates as a collecting cylinder together with the two printing plate cylinders 45 and 46, in that the rotating applicator cylinder 43 in each case successively

picks up a special ink from the printing plate cylinders 45 and 46 rolling on it and then applies the two special inks at once to the sheet 17. Each printing plate cylinder 44 to 46 is assigned a damping unit 49 to 51 for damping it, and an inking unit 42 to 54, designed as a vibrator-type inking unit, for inking it. The respective damping unit 49 to 51 can be dispensed with in the case of a second printing machine 8 and 9 that operates in the dry offset process. Each printing plate cylinder 44 to 46 can be assigned a laser source as an image-setting device 55 to 57 for the purpose of setting an image on it within the second printing machine 8 and 9 by means of laser radiation. The printing plate cylinder 46, the inking unit 54, if appropriate the damping unit 51 and if appropriate the image-setting device 57 are mounted between side plates which are separate from the side walls of the printing machine 9 but correspond to the latter in terms of distance and thickness and together form a structural unit in the form of a printing module 58 which can be placed onto the side walls.

Apart from the printing module 58, the second printing machines 8 and 9 are identical to each other. By leaving out the printing module 58, the second printing machine 9 can be converted to a single-color printing machine, which corresponds to that shown in Figure 3. By adding the printing module 58, the second printing machine 8 can be converted to a two-color printing machine, which corresponds to that shown in Figure 4. As a result of this building-block system, the manufacturer's production costs can be kept low.

In order to provide the sheets 17 with imprints that can be varied from sheet to sheet during continuous operation of the machine, for example continuous numbering or codes, an imprinting unit 59 with a stamping shaft 60 can be integrated both into the second printing machine 8 and into the second

printing machine 9, as is illustrated using the example of the second printing machine 8.

In order to dry the sheet 17 before it is delivered by the sheet deliverer 21 or 23, a dryer 61 can also be integrated instead of the single printing unit 59 into each of the aforementioned second printing machines 8 and 9, as is illustrated using the example of the second printing machine 9.

A dryer 62 to 65 can likewise be integrated into the sheet deliverer 21 to 24 of the second printing machine 6 to 9, being arranged between the two runs of the chain gripper of the respective sheet deliverer 21 to 24. The dryer 62 to 65 is assigned to the lower run, which conveys the sheets 17 and from which the sheets 17 are allowed to fall onto a sheet stack belonging to the respective sheet deliverer 21 to 24. The dryer 62 to 65 acts on the front side of the sheet 17 freshly printed in the second printing machine 6 to 9 while said sheet is being transported past the dryer 62 to 65 by the chain gripper.

For the purpose of transporting sheets from the first printing machine 1 into the respective second printing machine 6 to 9, a feed device 66 to 69 and a modular transport device 70 to 73 are installed between the sheet deliverer 11 of the first printing machine 1 and the second impression cylinder 29, 30, 47 or 48 of the second printing machine 6 to 9. Each of the transport devices 70 to 73, which are described in more detail below, can be installed instead of each of the other transport devices 70 to 73. For example, the transport device 70 can also be integrated instead of the transport device 71 into the printing machine system 3. The feed devices 66 to 69 are identical to one another.

Each transport device 70 to 73 is arranged between the first impression cylinder 12 and the respective second impression cylinder 29, 30, 47 or 48 to transport the sheets from the first impression cylinder 12 to the second impression cylinder 29, 30, 47 or 48, and is designed to transport the sheets 17 along a linear transport path 74 to 77.

An electric motor drive 118 which drives the first printing machine 1 and in particular the rotating system of the first impression cylinder 12 and the circulation of the sheet deliverer 11, a drive 119 which drives the second printing machine 6 to 9 and in particular the rotating system of the second impression cylinder 29, 30, 47 or 48, and an electric motor drive 120 which drives the transport device 70 to 73 and in particular its circulation, are linked to an electronic control device 121 and, via the latter, are linked to one another in control terms for the synchronization of the drives 118 to 120, as is shown using the example of the printing machine system 3. In order to prevent the gripper bars 89 and 90 of the transport device 71 colliding with the deliverer gripper bars, even in the case of accidents and, for example, in the event of failure of the control device 121, positive forcible control is provided in the form of a gear mechanism 122 which links the transport device 71 and the sheet deliverer 11, and whose gearwheel assigned to the sheet deliverer 11 and, for example, arranged coaxially with the chain sprocket 116, and whose gearwheel assigned to the transport device 71 and arranged, for example, coaxially with the chain sprocket 87, have an increased tooth clearance from one another and come into tooth-flank contact with one another only in the event of an accident.

The transport device 70 to 73 is assigned a non-impact printer 78 to 81 and, following the latter in the sheet transport direction, a dryer 123 to 126. The non-impact printer 78 to 81 prints the sheet 17 and the dryer 123 to 126 dries the sheet 17, while the latter is transported by the transport device 70 to 73 along the transport path 74 to 77 and past the non-impact printer 78 to 81 and past the dryer 123 to 126. The non-impact printer 78 to 81 is preferably an ink jet printer, from whose nozzles droplets of ink are expelled by piezoelectric pumps.

Each of the dryers 61 to 65 and 123 to 126 may be an IR (infrared radiation) dryer, a UV (ultraviolet radiation) dryer and, in particular, a so-called UV excimer dryer, which operates without forming any ozone and, with its monochromatic UV radiator at 308 or 222 nanometers light wavelength, does not emit any heat radiation. Such a UV excimer dryer is known, for example, from the publication "Druckwelt", Issue March 1999, and was developed, for example, by the Sächsisches Institut der Druckindustrie [Saxon Institute for the Printing Industry] (SID), Leipzig, on the basis of blue-light modules with mercury-free UV radiators from Heraeus Noblelight GmbH, Kleinostheim.

The dryers 123 to 126 are provided for the drying of the ink-jet ink printed by the non-impact printer 78 to 81, which can also be a UV-curable ink, said drying being rapid and essentially completed before the sheet 17 is printed or varnished in the second printing machine 6 to 9. The dryers 61 to 65 are provided to dry the entire sheet 17 before it is delivered in the sheet deliverer 21 to 24.

Instead of the ink jet printer, in some cases a laser printer can also be provided as the non-impact printer 81 to 84, it being possible for the dryer 123 to 126 to be dispensed with.

The advantage of the non-impact printer 81 to 84 over an imprinting unit which can be connected up mechanically, such as the imprinting unit 59, is that, by means of the non-impact printer 81 to 84, addresses, personalizations and virtually all conceivable motifs can also be printed onto the sheet 17, it being possible for the type and sequence of the motifs to be updated during the uninterrupted running of the printing machine system 2 to 5. In the imprinting unit 59, the type, the number and the sequence of the motifs, which here can be continuous numbering, codes and the like, for example, are predetermined by the design and indexing of the stamps or numbering wheels used in the imprinting unit 59, which can be replaced only with the machine at a standstill.

The transport device 70 is designed as an electromagnetic linear drive or linear motor, which comprises stators 82 and 83 and at least one rotor 84 and 85, the rotor 84 and 85 being equipped with at least one sheet holding element (not specifically illustrated) to carry the sheets 17, and the stators 82 and 83 being arranged along the transport path 74 of the sheets 17 and being designed to produce a traveling electromagnetic field to drive the rotor 84 and 85 forward.

The transport device 71 is designed as a chain gripper, which comprises a linked chain 88 which circulates about two shafts provided with chain sprockets 86 and 87, and to which at least one gripper bar 89 and 90 carrying the sheet 17 is fastened.

The transport device 72 is a suction belt that circulates around two shafts 91 and 92, consists of an air-permeable

material or is provided with air passages and which, in order to hold the sheet 17 on the suction belt, is assigned a pneumatic suction device 93 which attracts the sheet 17 by suction through the suction belt.

The transport device 73 is a transport belt which circulates around two shafts 94 and 95 and which has at least one tongs-type gripper 96 and 97 for holding the sheet 17, rests on that side of the held sheet 17 which is to be printed by the non-impact printer 84 and, on account of its ultra-flat design, when the sheet 17 is being transported past the non-impact printer 84, can be led without collision through a narrow gap 98 formed by the non-impact printer 84 and the sheet 17. Each tongs-like gripper 96 and 97, which can be moved relative to a gripper pad in order to clamp in the sheet and clamps the sheet in between itself and the gripper pad, is less than 1.0 mm thick, in particular less than 0.5 mm thick, and thus barely projects in the direction of the non-impact printer 84.

In addition, each gripper bar 89 and 90 of the transport device 71, and each rotor 84 and 85 of the transport device 70, can be equipped with such an ultra-flat tongs-type gripper 99 to 102 as a sheet-holding element.

The feed device 66 to 69 accepts the sheet 17 from the respective transport device 71 to 73, which in turn accepts the sheet 17 from the sheet deliverer, which is designed as a chain gripper which circulates around chain sprockets 116 and 117 and is provided with deliverer gripper bars (not specifically illustrated). The feed device, which is used to transfer the sheet to the second impression cylinder 29, 30, 47 or 48 and is designed as a feed drum, is assigned at least one actuating device 103 to 105.

In order to simplify the following explanations, the same reference symbols are used in Figures 1 to 4 for sensors, electronic control devices and the actuating devices which are constructionally and functionally identical in all the printing machine systems 2 to 5.

The first impression cylinder 12 is assigned at least one sensor 106 to 108 to monitor the position of a sheet 17 transported by said impression cylinder, and the feed device 66 to 69 is assigned at least one further sensor 109 to 110 to monitor the position of the sheet 17 to be transferred from the feed device 66 to 69 to the second impression cylinder 29, 30, 47 or 48. The at least one sensor 107 and 108 and the at least one further sensor 109 and 110 are arranged to monitor the position of a leading edge of the sheet and, via an electronic control device 112, are linked to the actuating device 103 that is used to adjust the circumferential register of the feed device 66 to 69. If only a single sensor 107 and 109 is assigned to the first impression cylinder 12 and the feed device 66 to 69 in each case to monitor the circumferential register, then said sensor is in each case situated in the area of the center of the format width of the leading edge of the sheet 17 passing by the sensor 107 and 109.

The sensors 107 and 108 are preferably arranged to be offset in relation to each other in the axial direction of the first impression cylinder 12, and form a first pair of sensors, and the sensors 109 and 110 are likewise preferably arranged to be offset in relation to each other in the axial direction of the feed device 66 to 69, and form a second pair of sensors. In terms of their pairwise arrangement, the sensors 107 to 110 are not arranged in the area of the center of the sheet but, as a function of the format, adjustably close to the side

edges of the sheet, so that the sensors 107 and 109 register the leading edge close to one side edge of the sheet, and the sensors 108 and 110 register the leading edge close to the other side edge of the sheet. The pairs of sensors can be used not only to monitor the circumferential register but, alternatively or additionally, also to monitor the diagonal or skew register. In this case, each of the four sensors 107 to 110 is linked via the electronic control device 112 to the actuating device 104 serving to adjust the diagonal register of the feed device 66 to 69 and, with simultaneous monitoring of the circumferential register, also linked to the actuating device 103.

In addition, an incremental encoder 113 for registering the machine angle of the first printing machine 1 - that is to say the rotary angle position of the rotating first impression cylinder 12 - is linked to the electronic control device 112 and, via the latter, to the sensors 107 to 110.

If the control device 112 establishes that there are deviations between the register values from the pair of sensors 107 and 108 or from the single sensor 107 in relation to the pair of sensors 109 and 110 or the single sensor 109, the control device 112 controls the actuating device 103 in such a way that the circumferential register of the feed device 66 to 69 is displaced in the circumferential direction of the feed device 66 to 69, corresponding to a register-maintaining setting. If the control device 112 establishes that the monitored values from the pair of sensors 109 and 110 deviate from the monitored values of the pair of sensors 107 and 108, the control device 112 controls the actuating device 104 in such a way that the diagonal register of the feed device 66 to 69 is set in a register-maintaining manner by changing their skew or parallel setting.

The sensors 106 and 111 are arranged so as to monitor the position of one side edge of the sheet 17, and are linked via the electronic control device 112 to the actuating device 105 serving to adjust the lateral register of the feed device. The sensor 106 measures the position of the sheet 17 on the first impression cylinder 12 in the axial direction of the latter, and signals the measured position to the control device 112. The sensor 111 likewise measures the lateral position of the sheet 17 on the feed device 66 to 69 and, in turn, signals the measured position to the control device 112, which, in the event of a deviation of the value measured by the sensor 111 from the value measured by the sensor 106, controls the actuating device 105 that serves to adjust the lateral register of the feed device 66 to 69 in such a way that, by means of displacing the feed device 66 to 69 axially, its lateral register is adjusted.

The adjustment of the feed device to correct the circumferential, diagonal or lateral register is carried out only after the trailing edge of the sheet transported by the feed device 66 to 69 during its displacement has passed by the non-impact printer 81 to 84, and this sheet is no longer being printed by the non-impact printer 81 to 84.

This reliably avoids any distortion of the image printed onto the sheet by the non-impact printer 81 to 84 as a result of the premature displacement of the sheet relative to the non-impact printer 81 to 84, which is still printing, by the feed device 66.

Each of the sensors 106 to 111 is designed as an optical sensor in the form of a so-called CCD (charge coupled device) line.

Instead of directly monitoring the position of the sheet leading edge or the sheet lateral edge by means of the respective sensor 106 to 111, register marks, for example register crosses, can be printed in the first printing machine 1 with the applicator cylinder 19 onto the sheet margins which are located at the edge of the sheet and are free of a printed image and whose position is registered by the respective sensor 106 to 111, by which means the position of the edge of the sheet is monitored indirectly.

After the register corrections described above have been carried out, the feed device 66 to 69 transfers the sheet 17, which has been printed in-register on the first impression cylinder 12 and whose maintenance of register had from time to time been lost as a result of the sheet transfer from the sheet deliverer 11 to the transport device 70 to 73 at a separating point 115, to the second impression cylinder 29, 30, 47 or 48, again while maintaining register.

On account of possible wear and the necessary play in a coupling device 114, it is not ruled out that the respective second printing machine 6 to 9, each time it is coupled up to the first printing machine 1, is offset slightly in relation to the latter by a different amount. This offset manifests itself at the separating point 115, at which the respective transport device 70 to 73 accepts the sheets 17 from the sheet deliverer 11, and at which the second printing machine 6 to 9 can be separated from the first printing machine 1. In other words, the sheet deliverer 11 transfers the sheets 17 more or less in-register to the respective transport device 70 to 73, depending on the magnitude of the offset.

The possibly inaccurate transfer register between the first printing machine 1 and the second printing machine 6 to 9 is advantageously compensated for by means of appropriate displacement of the feed device 66 to 69, so that the sheet 17 is in turn transferred with accurate register from the feed device 66 to 69 to the respective second impression cylinder 29, 39, 47 or 48.

Claims

1. A modular printing machine system (2, 3, 4, 5) for printing on sheets (17), comprising
a first printing machine (1) of satellite design, with a central first impression cylinder (12) and at least four printing devices (13, 14, 15, 16) assigned to the latter,
a second printing machine (6; 7; 8; 9), and
a coupling device (114) for coupling the printing machines (1, 6; 7; 8; 9) to one another for their in-line operation,
characterized in that the second printing machine (6, 7, 8, 9) includes at least one zoneless metering device (36, 37) to meter ink or varnish uniformly over the printing width.

2. The modular printing machine system as claimed in claim 1, characterized in that the metering device (37) comprises an engraved roll (38) and a doctor (39) set onto the latter - especially a chamber-type doctor.

3. The modular printing machine system as claimed in claim 1 or 2, characterized in that the metering device (36) comprises a trough (34), a dip roll (35) arranged in the latter and a metering roll (33) resting on said dip roll.

4. The modular printing machine system as claimed in one of claims 1 to 3, characterized in that the metering device (36; 37) is assigned to a single applicator cylinder (31, 32) belonging to the second printing machine (6, 7) and serving to apply ink or varnish to the sheets (17).

5. The modular printing machine system as claimed in claim 4, characterized in that the applicator cylinder (32) is a plate cylinder.

6. The modular printing machine system as claimed in claim 5, characterized in that a flexographic printing plate (41) for printing or varnishing is clamped onto the applicator cylinder (32).

7. The modular printing machine system as claimed in claim 4, characterized in that the applicator cylinder (31) is a rubber-blanket or varnishing-blanket cylinder.

8. The modular printing machine system as claimed in one of claims 1 to 7, characterized in that a second impression cylinder (47) of the second printing machine (8) is assigned a numbering or imprinting unit (59) with a rotatable shaft (60) which bears at least one numbering or imprinting stamp.

9. The modular printing machine system as claimed in one of claims 1 to 8, characterized in that at least one dryer (61 to 65, 116 to 120) - especially an excimer dryer - is integrated into the printing machine system (2, 3, 4, 5).

10. A modular printing machine system (2, 3, 4, 5) for printing on sheets (17), comprising
a first printing machine (1) comprising a sheet feeder (10) and of satellite design with a central first impression cylinder (12) and at least four printing devices (13, 14, 15, 16) assigned to the latter,
a second printing machine (6; 7; 8; 9) comprising a sheet deliverer (21; 22; 23; 24) and a second impression cylinder (29; 30; 47; 48),
and a coupling device (114) for coupling the printing machines (1, 6; 7; 8; 9) to one another for their in-line operation,
in particular as claimed in one of claims 1 to 9,
characterized in that the impression cylinders (12 and 29; 30; 47; 48) are of different sizes.

Abstract

The invention relates to a modular printing machine system (2) for printing on sheets (17), comprising a first printing machine (1) of satellite design, with a central first impression cylinder (12) and at least four printing devices (13 to 16) assigned to the latter, a second printing machine (6), and a coupling device (114) for coupling the printing machines (1, 6) to one another for their in-line operation.

The printing machine system is distinguished by the fact that the second printing machine (6) includes at least one zoneless metering device (36) to meter ink or varnish uniformly over the printing width.

(Figure 1)